



Finishing Details

Curbs placed directly on the surface of a wood deck can cause the deck planking to rot. Leaves, needles, and dirt accumulate against the curb, absorb water, and cause additional rot. During the winter, ice and snow will build up on the deck, causing a hazardous condition.

To keep the deck from rotting, place the curbs on blocks. A finished block of 2 by 4 lumber is only 1½ inches thick. Leaves and dirt can still build up against the curb and under it. With just 1½ inches of space between the curb and the deck, it is difficult to get a shovel under the curb, making this area almost impossible to clean. A better solution is to use two blocks of 2 by 4 lumber, one on top of the other, or one block of 4 by 4 lumber (figure 65). The increased clearance under the curb will not trap litter, and melting ice and snow will run off more quickly.

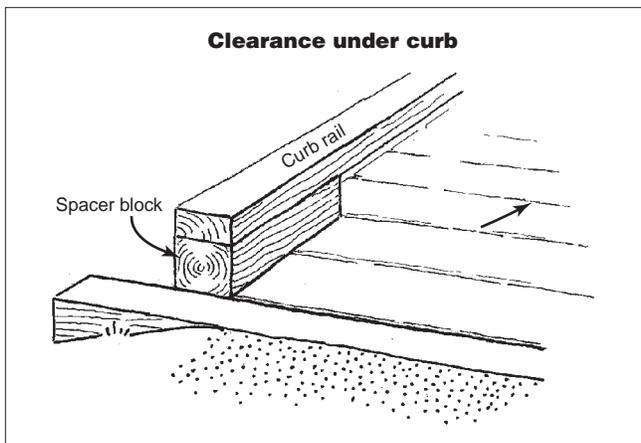


Figure 65—Having at least 4 inches of clearance under the curb is best.

Bulkheads (End Dams, Faceplates)

Bulkheads must be installed where wood construction meets the earth trail at each end of a puncheon, bog bridge, or boardwalk. Faceplates function as retaining walls to support the earth. They also protect the end grain of the stringers from rot and insect damage (figure 66).

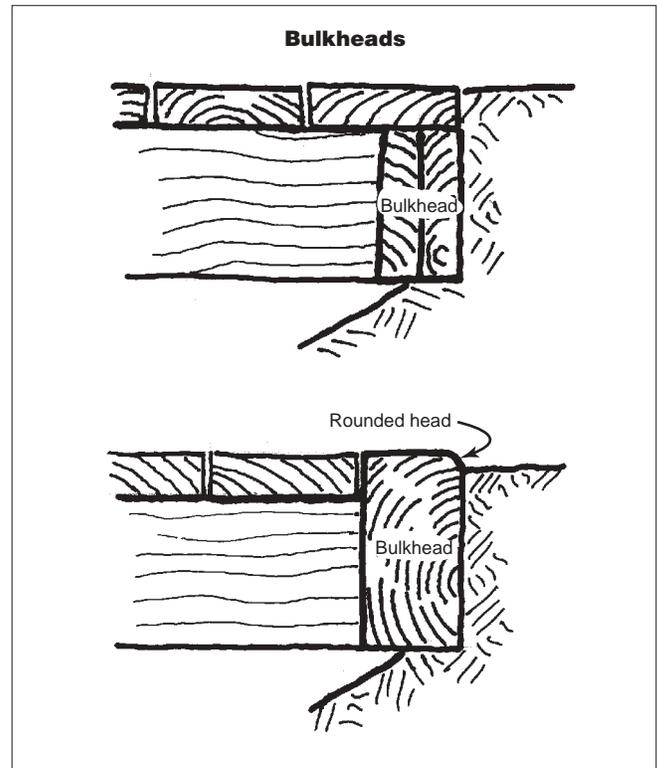


Figure 66—Bulkheads serve as retaining walls to support the earth, and they protect the stringers from rot and insect damage. Here are two different ways to install them.

There are two ways to install a faceplate, depending on the climate. The faceplate may be installed with its top level with the top of the deck. This installation will leave a small gap between the deck plank and the faceplate, allowing some water to percolate down to the absorbent end grain of the stringer. In a dry climate, the amount of water is negligible. However, in a wet climate it is common to install the faceplate's top level with the top of the stringers, covering the gap with a piece of deck plank. If the faceplate is level with the deck, the exposed outside edge should be rounded to a ½- to 1-inch radius.



Floating Trails

Trails that float on the surface of the water are quite rare. They are covered briefly here. The Missoula Technology and Development Center is planning a more detailed report on this topic.

Most floating trails are engineered structures, like docks, that float on watertight drums, polystyrene-filled corrugated plastic pipe, or other specialized floating systems. Rely on your engineering and landscape architectural staff to help you design a functional, attractive system.

A floating trail needs solid anchors at each end. Depending on the length of the floating trail and the expected water condition, the anchors may be timber deadmen (buried anchors), helical piles, concrete deadmen, or long wooden piles. Two cables, connected to these anchors and the opposite ends of each float, hold the floats in place. The trail must be straight between anchor points. Bends in the route require intermediate anchor points for the cables. If there is any current, an additional cable brace should be attached to the floats toward the middle of the span to hold them in place against the current. This cable brace must also be anchored on both ends. You may need to install cable braces on both sides of the floating trail to hold it in place (figure 67).

A floating trail tends to bob around, creating an unsteady tread surface. Such trails may not be suitable for all users. During periods of rough water, the floating trail may have to be closed.

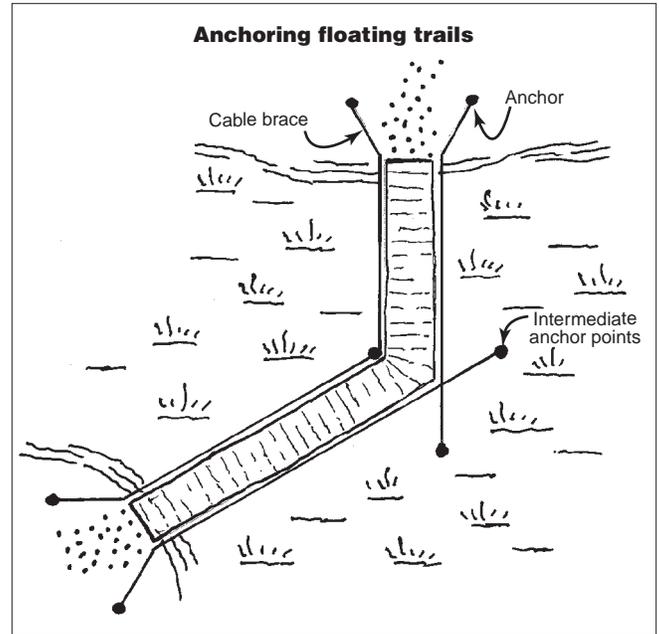


Figure 67—True floating trails need solid anchorages. Often they are secured with wire rope.



Construction Materials

Choosing Materials

Materials used in trail design should be appropriate for the setting. Steel, plastic, concrete, and asphalt may be appropriate in an urban greenbelt, but out of place in the backcountry. Log construction, stone masonry, and dirt trails are appropriate in a primitive, backcountry setting, but out of place in a city.

The Forest Service recognized this problem in the late 1970s and developed a system called the Recreational Opportunity Spectrum (ROS).

The ROS system establishes seven types of recreational land uses and describes the level of development, management, and construction materials suitable for each of them. The ROS principles may appear overly structured, but their application should result in construction and management that is compatible with the environment surrounding a wetland trail whether that trail is in a remote area, an urban greenbelt, or another setting. The ROS concepts are too detailed to include here, but they should be understood by anyone planning to design and construct wetland trails.

Logs

Wood from logs cut onsite is commonly used in trail construction, but wood is susceptible to attack by insects and fungi. Bark separates from the wood. The gap collects water and provides shade and protection for insects and fungi. Peeling off the bark reduces the likelihood of these attacks. Depending on local conditions, removing the bark may double the life of a log.

The bark can be removed by hand or machine. Using a drawknife or bark spud is the traditional way of peeling logs. The random scrape marks left on the peeled logs gives them a rustic appearance. Machine peeling “chews” the bark and some of the wood in a spiral pattern. The finished pieces are almost uniform in size, with a machined appearance that lacks the rustic character of peeled logs.

Wood that is exposed to the weather or is in contact with the ground will eventually require replacement. In wetlands, a flood, a heavy snow, a buildup of ice, fallen trees, or animal damage may shorten the life of wooden materials. Trees growing near a wetland site are unlikely to provide a sustainable source of logs for replacement structures. Even in remote areas, logs cut from trees growing in the vicinity may not be the best choice of materials.

Using logs cut onsite for trail construction is an inefficient use of wood and does not represent sustainable design. Tearing up areas near a site and destroying the character of the wetland makes no sense. Today, responsible trail crews are taking commercially obtained logs and other wood materials to remote wetland sites by boat, horse, mule, off-highway vehicle, by hand, or by helicopter, even when adequate material is growing a few feet from where it could be used. Sometimes materials can be hauled in more easily over snow during the winter for use the following summer.

Lumber and Timber

For the purposes of this text, lumber is wood that has been sawed and planed into uniform pieces with a minimum dimension of 2 inches or less. For instance, a 2 by 6 is a piece of lumber. Timber is wood that has been sawed into more or less uniform pieces, with a minimum dimension of at least 3 inches. Usually, timbers have not been planed smooth.

It helps to understand how logs are processed into lumber and timbers. Logs run through a sawmill are typically sawed into standard-size pieces, usually 1-inch thick or in increments of 2 inches. Common sizes are: 1 by 4, 1 by 6, 2 by 4, 2 by 6, 2 by 8, and 4 by 4. The pieces can also be cut into 3-inch stock. However, such nonstandard timbers would not be readily available at the local lumberyard. Most 4-by-4, 6-by-6, and larger timbers are cut from the center of the log. Generally 1- and 2-inch materials are cut from the outside of the log.

After the pieces of wood are cut from the log, they are referred to as rough sawn. The first step produces a piece that is sawn on its two widest faces. The bark remains on the narrow edges. At this point the piece is described as rough sawn and waney edged. The edges are not parallel or square. Waney-edged wood is used for rustic siding. Waney-edged lumber can be special ordered (figure 68).

Next, the piece of wood is run through another saw, the edger, that trims the edges square and to a standard 2-inch dimension. The piece of wood is now rough sawn on all four sides and is full size—a 2 by 4 is 2 inches thick, 4 inches wide, and as long as the log.

The pieces are cut to standard lengths. Normally, the shortest pieces are 8 feet long. Longer pieces are cut in multiples of 2 feet, up to 16 feet. Rough-sawn lumber or timbers can be ordered. A piece of rough-sawn, 2-inch lumber is considerably heavier than the finished lumber normally carried at a lumberyard. Rough-sawn pieces are not completely uniform.

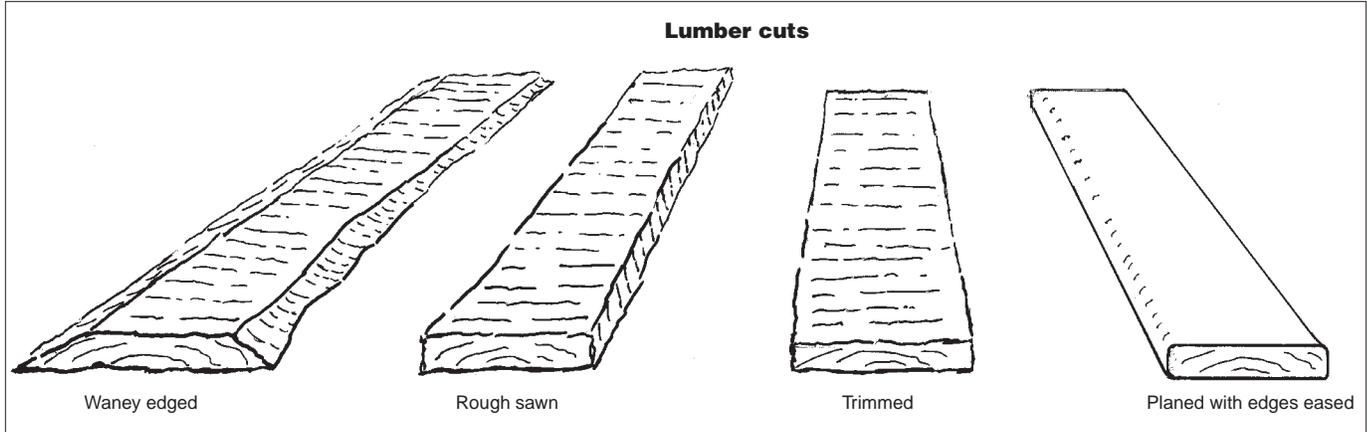


Figure 68—Lumber terminology.

Depending on the capability of the sawmill, similar pieces may vary $\frac{1}{8}$ to $\frac{3}{8}$ inch from each other. The pieces will not have a smooth surface, and the edges will be sharp and splintery.

Finally, the rough-sawn pieces are run through a planer. The planer removes enough wood to smooth the surface on all sides and to produce standard-size pieces. After planing, a 2 by 4 is $1\frac{1}{2}$ inches by $3\frac{1}{2}$ inches and is described as S4S (surfaced four sides). The size after the lumber has been surfaced on all four sides is referred to as nominal size.

Most 2-by-4 material is usually run through a special planer to round off the corners. This process is called edges eased and reduces the chances of splinters when handling the wood. Edges eased can also be specified for other dimensions of lumber and the smallest dimension timbers, but must be special ordered.

Waney-edged material should be less expensive than rough-sawn because it requires less processing. Rough-sawn material should also be less expensive than nominal-size material because it has not been through a planer or had the edges eased. If the imperfections of waney-edged or rough-sawn material are acceptable, there is no point in specifying the nominal size material for a project. Why pay for someone to turn wood into sawdust and shavings that you can't use? Besides, the additional work results in a weaker piece of wood.

Wholesalers sell wood by the thousand board feet. A board foot is 12 inches by 12 inches and 1 inch thick, or 144 cubic inches. The board footage of lumber and timber is determined at the time the piece of wood is rough sawn. See appendix E for a table of board feet contained in most standard sizes of lumber and timber, and for various standard lengths.

Rot-Resistant Wood

Using rot-resistant wood will greatly increase the life of the material and reduce maintenance. Some species of trees are naturally rot resistant. Wood from other species can be treated with preservatives to extend its life. Depending on the climate and the location of the piece of wood in the finished work, construction without rot-resistant wood may last only 7 to 10 years, while installations of naturally rot-resistant woods may last 70 years or more.

Naturally Rot-Resistant Wood

The most common rot-resistant species are the various cedars, redwood, tamarack, baldcypress, and black locust. A tannin found in the wood of these trees colors the heartwood and makes it rot and insect resistant. The sapwood of the same tree is almost white and is not resistant. The wood of Douglas-fir and the white oaks does not contain a toxin, but it is dense enough to repel some fungus and insect attacks.

Preservative-Treated Wood

Using chemically-treated wood in wet environments may mean the structure lasts 30 years instead of 7 to 10 years. It is important to know which chemical treatments are appropriate, and whether or not they cause adverse health or environmental effects.



Construction Materials

The subject of chemically-treated wood is complex, and is an area of continuing research and product development. Refer to the references section for good sources of information. In particular, always follow the recommendations in the *Best Management Practices for the Use of Treated Wood in Aquatic Environments*, developed by the Western Wood Preservers Institute.

In a nutshell, there are several good reasons to use preservative-treated wood in wet areas and few reasons not to use them. All of the treatments effective in wet areas must be applied under pressure in a factory to exacting standards. The exception is copper naphthenate, which can be applied carefully and sparingly with a brush and is good for spot treatment. Both oil-type and waterborne preservatives are suitable for wet environments from a standpoint of preserving wood, but the person specifying materials needs to know the characteristics and effects of each type of preservative before deciding which to use. Water-soluble preservatives, such as borates, are not suited for wet environments. The borates do not permanently “fix” to the wood.

Workers need to take safety precautions when handling or disposing of treated wood. Treated wood should not be burned. Some States and other jurisdictions may also impose disposal restrictions.

Each of the preservatives containing copper imparts a color that disappears in time. Normally, the color disappears within 2 years, but depending on site conditions and exposure, the process may take several months to 3 or 4 years. Stains can be added to the waterborne preservatives at the time of treatment or anytime thereafter. Pigments, stains, and dyes mask the normal color of the preservative. Because these materials will penetrate the wood during treatment, future needs for restaining will be reduced. Treatment plants will be reluctant to apply any special stains to wood unless they are processing a very large order.

Recycled Plastic

Many manufacturers of recycled plastic are producing this material in the shapes and dimensions of standard wood lumber and timber products. Some of these products are being marketed as premium deck coverings. Recycled plastic can be worked like wood. It can be sawed, drilled, nailed, screwed, bolted, and painted. Although the surface is smooth, it is not slippery.

The properties of some recycled plastic may present unexpected challenges and disappointments. The material can be up to

three times heavier than wood. By itself, 100-percent recycled plastic has little strength. It must be reinforced with a steel backing or core to have any structural value, increasing its weight and introducing another material. Plastic is rot resistant. The thermodynamic properties of plastic—how much it expands and contracts in the heat or cold—are quite different from those of concrete, steel, or wood, the materials that would normally be used with recycled plastic. The surfaces of some recycled plastic severely degrade in sunlight. The problems of strength, thermodynamics, and ultraviolet degradation are being studied. These problems have resulted in new, improved formulations of recycled plastic. These products have not yet withstood the test of time.

Some recycled plastics contain sawdust or another form of wood fiber or fiberglass. These composites are usually stronger and do not have the same thermodynamic problems as most 100-percent plastics. When sawed or drilled, the exposed sawdust and wood fiber may be just as subject to fungus and insect attack as untreated wood. However, wood fibers completely encased in plastic will still be rot resistant. Fiberglass resists rot. Composites containing fiberglass are rot resistant.

A problem is created when any of the recycled plastics are drilled or sawed in the field. Unlike wood, the shavings and sawdust will not decompose. This problem can be resolved by drilling and sawing over a large plastic sheet and carrying the shavings out.

Recycled plastic is not a traditional construction material. It may be inappropriate where a rustic appearance is important. Recycled plastic costs 50 to 300 percent more than treated wood. The increased weight of plastic will be reflected in higher shipping and onsite construction costs. One advantage of this plastic is that it does not support combustion.

Hardware Connectors

The nails, bolts, washers, nuts, and other connectors used for outdoor construction should be made of corrosion-resistant steel. Hot-dipped galvanizing provides more durable protection than electroplating. Products commonly available at most building supply stores are electroplated. It is especially important to use galvanized connectors on wood that has been treated with waterborne preservatives containing copper. Most connecting hardware is now available as corrosion-resistant (weathering) steel, another good choice.



Nails

Most nails used in trail construction are ringshank nails, barn spikes, or occasionally, roofing nails. Ringshank nails have closely spaced circular rings around the shank of the nail. These nails rarely work loose and are very difficult to remove if driven incorrectly. The steel is quite brittle. It will usually break off if it is bent or hit on the side. Nails are sized by the penny, an old form of measurement. See appendix D for gauge (thickness), lengths, and number of nails per pound for each size. Barn spikes are from 8 to 12 inches long, with a wide thread making a complete revolution around the shank every 4 to 6 inches.

Bolts

Bolts are used for constructing bents. Bolted connections are better than screwed connections because the bolt passes completely through at least two timbers or a timber and a steel plate or angle. Both ends of the bolt are visible and can be tightened if the wood shrinks. Three different types of bolts can be used: carriage bolts, machine bolts, and long bolts that are custom cut from threaded rod (called *all thread*).

Carriage bolts were used to construct wooden wagons and carriages. A square portion of the head of a carriage bolt penetrates into the wood, preventing the bolt from turning when it is tightened. Carriage bolts were originally used with oak, a hardwood that did not allow the bolt head to turn. Carriage bolts are effective with most woods, except for softwoods such as redwood and western redcedar. Carriage bolts do not require washers between the head of the bolt and the wood, but a washer is needed between the nut and the wood. Carriage bolts may be up to 12 inches long.

Machine bolts have a hexagonal head that is flat on the top and bottom. Machine bolts require steel between the head and the wood and between the nut and the wood. The steel can be either a washer or a steel angle or plate. Machine bolts may be up to 12 inches long.

All-thread rods are available in lengths of 2, 3, 6, and 12 feet and diameters of $\frac{1}{4}$ to 1 inch. The rod, threaded for its entire length, is useful where long bolts are needed. The appropriate length is cut from the long rod with a hacksaw, and a nut and washer are attached to each end. Bolt cutters should not be used to cut the rod. They will mash the threads, making it impossible to attach the nut (figure 69).



Figure 69—Fasteners (from left): carriage bolt, machine bolt, threaded rod, and lag screw.

Lag Bolts (Lag Screws)

Most people working with these connectors refer to them as lag bolts. Manufacturers call them lag screws. Regardless of their name, they usually have a square or hexagonal head, a threaded tapered shank, and a sharp point. They must be tightened with a wrench. They are made in lengths from 1 to 8 inches and diameters from $\frac{1}{4}$ to $\frac{5}{8}$ inch.

Washers

Four types of washers are suitable for working with wood in a wetland trail: flat washers, fender washers, lockwashers, and malleable iron washers. Flat washers are the most commonly



Construction Materials

used. They are placed between the wood and nuts and between the wood and the head of machine and lag bolts. The washer prevents the bolt head or nut from being drawn into the wood. Fender washers are wider than flat washers, but they have the same purpose. Fender washers are used if the wood or other material is soft. Lockwashers are not a closed circle; they are cut once and the ends are offset on one side or the other. They are used with the other washers and against the nut to prevent the nut from loosening.

Malleable iron washers are much larger and thicker than other washers. These washers were used when large-diameter bolts joined logs and heavy timbers in traditional rustic construction. Malleable iron washers can be used with $\frac{3}{8}$ - to 1-inch-diameter bolts.

Nuts

Nuts fit over the threaded ends of carriage and machine bolts and all-thread rod. They must be used against a washer or a piece of structural metal. Nuts are either square or hexagonal, with a round, threaded hole in the center to fit over the bolt or rod. Locknuts fit more snugly on the bolt than common nuts. They are used when vibration may loosen a common nut. Locknuts function better than lockwashers, but they are not as readily available.

Wood Screws

A screw is threaded and tapers to a point. The use of a screw determines the desired shape of the screw's head and point, and the material from which it is made. There are perhaps 100 kinds of screws, but wood screws are the ones most likely to be used in wetland trail construction. Wood screws are used to attach tread plank to a nailer, or an interpretive sign to a post. The head of a wood screw is wedge shaped to penetrate into the wood without protruding above the surface. Most screw heads will either have a recessed slot or cross to accommodate a standard screwdriver or a Phillips-head screwdriver. Hot-dipped galvanized steel, stainless steel, and brass screws should be used for trail work.

Most stainless steel wood screws are produced with a hexagonal recess in the head to accommodate an Allen wrench, which makes them somewhat vandal resistant. Other vandal-resistant screws require special screwdrivers for removal. These screws are best for installing signs.

Steel Reinforcing Bars

Steel reinforcing bars used for drift pins must be protected from the weather and the copper in wood treated with preservatives. Epoxy-coated steel reinforcing bars are available from suppliers of heavy construction materials. Usually these suppliers sell only to contractors. Epoxy can be purchased from some mail-order companies. The crew building the trail can cut the uncoated bars to size and dip the ends and paint the bars with the epoxy compound. The epoxy coating will resist saltwater corrosion. Before epoxy compounds were available, steel drift pins were protected with a thin layer of heavy automobile grease. The grease also made driving the drift pins easier.

Staples

Heavy steel fence staples, $\frac{1}{4}$ to $\frac{1}{2}$ inch in size, are useful for attaching hardware cloth to wooden piles used for bog bridge and boardwalk in areas frequented by beavers. Staples can also be used to attach geotextile fabric to wood.

Hardware Cloth

Hardware cloth consists of two sets of steel wires placed perpendicular to each other and welded together. The result is a pattern of equal squares. The squares are either $\frac{1}{4}$ or $\frac{1}{2}$ inch. After welding, the hardware cloth is hot-dipped galvanized. It is available in 20- and 50-yard rolls, and in 2-, 3-, and 4-foot widths (figure 70). Hardware cloth is sometimes stapled around piles to discourage beavers from chewing on them.

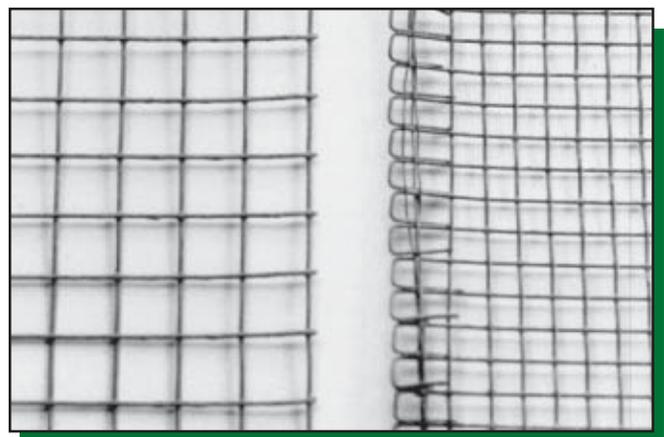


Figure 70—Two sizes of hardware cloth.

Geosynthetics

Geosynthetics are synthetic materials used with soil or rock in many types of construction. Geosynthetics can improve construction methods and offer some alternatives to traditional trail construction practices.

The Missoula Technology and Development Center produced a detailed report, *Geosynthetics for Trails in Wet Areas: 2000 Edition* (0023-2838-MTDC), about these versatile products. The following information is summarized from that report. See the references section for information about obtaining a copy.

Geosynthetics perform three major functions: separation, reinforcement, and drainage. Geosynthetic materials include geotextiles (construction fabrics), geonets, sheet drains, geogrids, and geocells. All these materials become a permanent part of the trail, but they must be covered with soil or rock to prevent ultraviolet light or trail users from damaging them.

Geotextiles, sometimes called construction fabrics, are the most widely used geosynthetic material. They are made from long-lasting synthetic fibers bonded to form a fabric. They are primarily used to separate trail construction materials from wet, mucky soil and to reinforce the trail. They have the tensile strength needed to support loads and can allow water, but not soil, to seep through. Nonporous geotextiles can be used in drainage applications to intercept and divert groundwater. Felt-like geotextiles are easier to work with than heat-bonded, slit-film, or woven products that have a slick texture.

Geotextiles are often used in trail turnpike or causeway construction. They serve as a barrier between the silty, mucky soil beneath the fabric and the mineral, coarse-grained, or granular soil placed as tread material on top of the geotextile. The importance of separation cannot be overemphasized. Once mineral soil contains about 20 percent of silt or clay, it takes on the characteristics of mud—and mud is certainly not what you want for your tread surface. Most geotextiles commonly used in road construction work for trail turnpikes. The fabric should allow water to pass through it, but have openings of 0.3 millimeters or smaller to prevent silt from passing through.

Geotextile is sensitive to ultraviolet light. It readily decomposes when exposed to sunlight. When geotextile is not exposed to sunlight, it lasts indefinitely. Always store unused geotextile in its original wrapper.

Geonets or geonet composites (figure 71) have a thin polyethylene drainage core that is covered on both sides with geotextile. They are used for all three functions—separation, reinforcement,

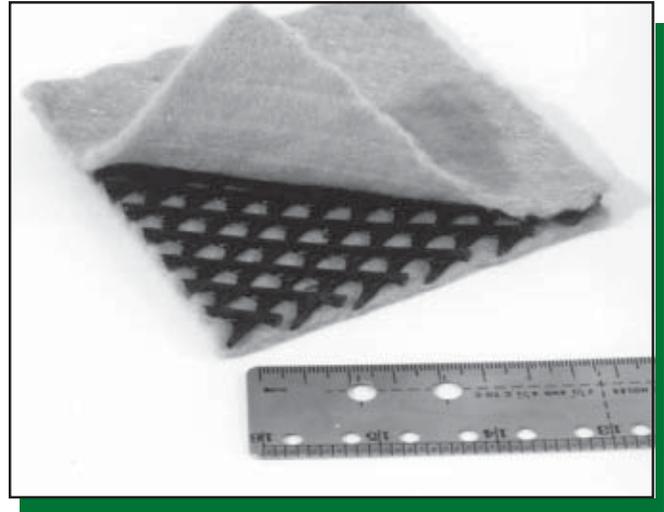


Figure 71—The net-like core of geonet allows drainage.

and drainage. Since geonets have a core plus two layers of geotextile, they provide more reinforcement for the trail than would a single layer of geotextile.

Sheet drains are a form of composite made with a drainage core and one or two layers of geotextile. The core is usually made of a polyethylene sheet shaped like a thin egg crate. The core provides separation, reinforcement, and drainage. Since sheet drains have greater bending strength than geotextiles or geonets, less tread fill is often needed above them.

Geogrids are made from polyethylene sheeting that is formed into very open grid-like configurations. Geogrids are good for reinforcement because they have high tensile strengths, and because coarse aggregate can interlock in the grid structure. Geogrids are normally placed on top of a layer of geotextile for separation from saturated soil.

Geocells (figure 72) are usually made from polyethylene strips bonded to form a honeycomb structure. Each of the cells is filled with backfill and compacted. Geocells are good for reinforcement, reduce the amount of fill material required, and help hold the fill in place. Geocell usually has geotextile under it to provide separation from saturated soils. The grids need to be covered with soil so they will never be exposed. Exposed geocells present a substantial hazard to vehicles due to loss of traction, and can cause hikers or packstock to trip.



Figure 72—Geocell usually has geotextile underneath to provide separation from saturated soils. Here a narrow strip of geocell is the first course of a retaining wall.

Non-slip Gratings and Grit-Treated Mats

Gratings are normally used for walking surfaces at industrial sites and boat docks. They may be useful where a slippery tread in a wetland trail has become a problem, or where this problem can be anticipated because of deep shade, heavy rainfall, or icy conditions.

Gratings are made in a variety of sizes from steel, stainless steel, aluminum, and fiberglass. Some manufacturers use fine serrated teeth on the surface of the grating to prevent users from slipping; others use small, round, raised knobs on the surface; still others embed silica grit. The gratings can be attached to an existing deck or used by themselves in the original construction.

Other options to reduce the likelihood of users slipping on the trail include the use of strips of rubber-like material with a non-skid surface. The strips adhere to clean decking. When wood is painted, stained, or sealed, a nonskid additive (sold at paint stores) can be mixed with the paint, stain, or clear sealer before they are applied.

Silica-treated fiberglass mats are available from some of the grating manufacturers. They come in thicknesses of $\frac{1}{8}$ to $\frac{3}{4}$ inch and in panel sizes of 5 to 12 feet. Fiberglass can be sawed to size. Holes can be drilled for nailing or screwing fiberglass to wood planks.

Most gratings are extremely expensive, well beyond the budgets of most trail projects. The exceptions would be for wetland trails at very heavily used sites such as visitor centers or for short interpretive trails.

In Alaska, slippery surfaces are a reality on miles and miles of boardwalk. The Forest Service Alaska Region's *Trails Construction and Maintenance Guide* (1991) offers several ways of dealing with this problem. These methods are described next.

Roughened Wood Surface

Use a saw or adz to cut grooves perpendicular to the line of travel. Make the cuts deep enough to be effective, but not so deep that they hold enough water to cause rot.

Mineral Paper

Mineral paper is available in a 9-inch width in 50-foot rolls. This tar-fiberglass material is tacked down every 3 to 4 inches along each edge with galvanized roofing nails. Mineral paper should be used on pressure-treated wood because it will hasten the decay of untreated wood. If properly installed, it has given good service for up to 10 years. Mineral paper is inexpensive and easy to replace.



Construction Materials

Fishing Net

Nylon fishing net (No. 96 Bunt Web) has been used successfully in the Alaska Region and has been found to be durable and effective. Make sure the net is properly stapled to each pressure-treated plank before delivering and installing the planks. Use an air-driven pneumatic stapler (that can be rented with an air compressor) to drive galvanized staples. Staple at 4-inch intervals to keep the net from bunching and creating a tripping hazard. The netting can be applied in the field using hand-driven galvanized fencing staples.

Neatly hide all edges underneath the walking surface of the plank or logs. Black 1- to 2-inch mesh netting has been used

successfully on trails in Alaska. The color blends into the landscape. Used net material can usually be obtained free from net hangers in most Alaska fishing towns.

Cleats

Cleats, narrow boards screwed or bolted perpendicular to the tread at step-sized intervals, are an effective way to reduce slipping, especially on slopes. Metal cleats are common on steep gangways leading to docks subject to tidal fluctuations.



Construction Tools

The standard tools used for trail construction are also needed for building a trail in a wetland. Standard trail tools are not described here. Instead, this report focuses on tools specifically needed for wetland trail construction. Find out more about handtools in MTDC's *Handtools for Trail Work* report (8823-2601-MTDC) and video (98-04-MTDC).

Measuring Tapes

Measuring tapes are a necessity for estimating and constructing a wetland trail. Construction measurements for wetland trails are often taken from the trail centerline. It is frequently necessary to divide by two. Metric measurements offer an advantage over English measurements in such cases. In addition, there is a move from the English system of measurement to the metric system (appendix F). Buy new tapes that are graduated in both systems.

Tapes 50 feet and longer are made of fiberglass, cloth, or steel. Fiberglass is best for the wet, brushy environment of wetlands. Cloth is not recommended because it will wear and rip easily. Long steel tapes may rust, kink, and break when used in wetlands. Short steel tapes, 6 to 30 feet long, are essential.

The longer tapes are best for estimating quantities of materials and hours needed for construction and for laying out centerlines of sleepers, bents, and other structures. The shorter steel tapes are handy for the actual construction.

Framing Squares

Framing squares (figure 73) are thin, L-shaped pieces of steel with a 90-degree angle at the corner. Each leg of the L is 1 to 2 inches wide and graduated in inches (or centimeters) from both the inside and outside corners of the L. The legs may be 8 inches to 2 feet long. Framing squares are used to mark hole centers and timbers to be cut at a 90-degree angle and to provide a straight, firm edge for marking angled cuts.

Plumb Bob

A plumb bob is a solid steel or brass cone, 3 inches long by 1½ inches in diameter. The plumb bob accurately transfers

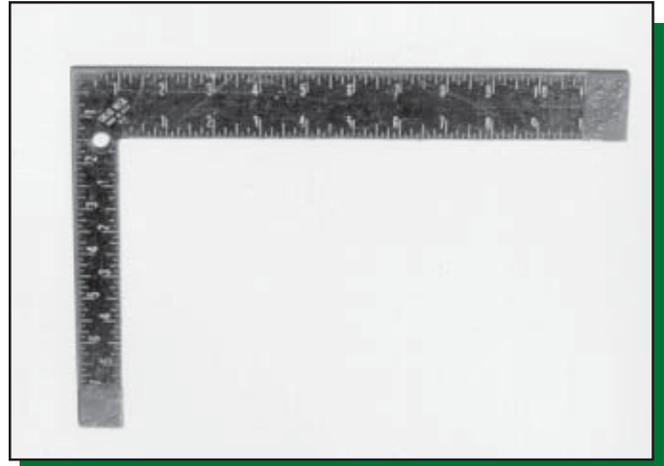


Figure 73—Framing square.

measured points above the ground to comparable points on the ground. It is useful for locating the centers of holes to be dug.

Levels

Specialized levels are useful for wetland trail work. An Abney hand level or a clinometer is accurate enough to be used for setting grades during the preliminary layout of most wetland trails (figure 74). String or line levels and carpenters and masons levels are needed during construction.



Figure 74—Use a clinometer to set grades for preliminary trail layout.

String or Line Levels

There are two types of string or line levels: one establishes percent of grade easily, the other does not. Each level is about 3 inches long by $\frac{1}{2}$ inch in diameter and has a hook at each end to hang the level on a string. The string is pulled tight between two points in an almost horizontal line. One of the points must be at a known elevation. The string level will be used to establish the elevation of the other point.

The most common type of string level has two marks on the level tube. These marks are equidistant from the high point of the level tube. Center the level bubble between the two marks on the tube by raising or lowering the string at the second point. When the bubble is centered, the string is level. If the tread is to be level, this is the elevation to be met. If the tread is to be sloped, the difference between the two points must be calculated; the elevation to be met is established by measuring the difference needed, up or down, from the level line.

In the second type of string level, the high point of the level bubble is off center. The level tube has five graduations. The first two are widely spaced. The rest are closer together, but evenly spaced. When the bubble is centered between the two widely spaced marks, the string is level. When the edge of the bubble touches the third mark, the string is at a 1-percent grade, the fourth mark is at a 2-percent grade, and so forth. A string level is accurate enough to begin to establish relative elevations and slopes for small wetland trail projects (figure 75).



Figure 75—String levels and a chalkline.

Stringlines

Almost any type of string can be used for a stringline, but for repeated use a professional stringline is best. This type of stringline is a tightly braided string wound around a short, narrow piece of wood, plastic, or metal. Usually there is a metal clip, or a loop, tied on the end.

The stringline extends a straight line to reference the location of the next section of construction. The stringline can also be used with string levels to establish relative elevations and slopes.

Chalklines

A chalkline is another type of stringline used to mark a straight line between two points on a flat surface. The marked line is commonly a guide for sawing.

Professional chalklines come in a metal case that holds the coil of string and the chalk dust. One end of the chalkline is held tightly at a fixed point on the surface of the object to be marked. The chalkline is stretched to the mark at the opposite end and held tightly at that point. Hold the chalkline at about midpoint, pull the chalkline straight up from the surface and release it. The chalkline will snap back into place, leaving a sharp, straight line of chalk between the two points.

A chalkline is useful for marking the centers of sleepers and bents for a deck that needs to be in a straight line, or the edges of a deck to be trimmed uniformly, or the edges of a log to be cut with a flat face.

Carpenters and Masons Levels

There used to be a distinction between carpenters levels and masons levels. Carpenters levels were wood or wood with steel strips to protect the edges. The masons level was all or mostly steel. Today, wood, steel, aluminum and plastic are used in either type of level.

These levels are available in lengths of from 2 to 6 feet. Given the abuse trail tools take, steel or aluminum levels are best. A 3- to 4-foot-long level is more accurate than shorter levels. These levels are easier to pack than 5- to 6-foot-long levels. Plastic levels are also available and cost less.



Construction Tools

The levels have three tubes mounted in the body of the level. One level tube is parallel with the length of the level, one is perpendicular to it, and one is at 45 degrees to the other two. When a level bubble is centered, the edge of the level is either level, vertical, or at 45 degrees.

Torpedo Levels

A torpedo level is steel or aluminum and plastic and only 8 to 12 inches long and 1 to 2 inches wide. It is used to determine if a surface within a confined area is level, for example the surface of a notch. Although the torpedo level is not as accurate as the longer levels, it can be used to check whether an item is out of level, or out of plumb. If so, a more accurate level can be used to make the corrections.

Post Levels

Post levels save time when setting posts and piles. They are basically plastic right angles that are 4 inches long in three dimensions. Two level tubes are mounted in the two faces of the level. Set the level along the side of the post or pile, and use a crowbar or shovel to adjust the post or pile until it is plumb (figure 76).

Surveyors Transits and Electronic Instruments

Hand-held tapes and levels are adequate for short destination or loop trails in a wetland, or for low, poorly drained sections of existing trails. However, for trails longer than a quarter mile or over undulating terrain, more precise measurements might avoid future problems. Control points for elevation and slope can be established using surveyors transits or a variety of electronic instruments.

Surveyors Levels or Transits

Old surveyors levels or transits may be hiding in a closet or storage area at some agency offices. Blow the dust off and try to

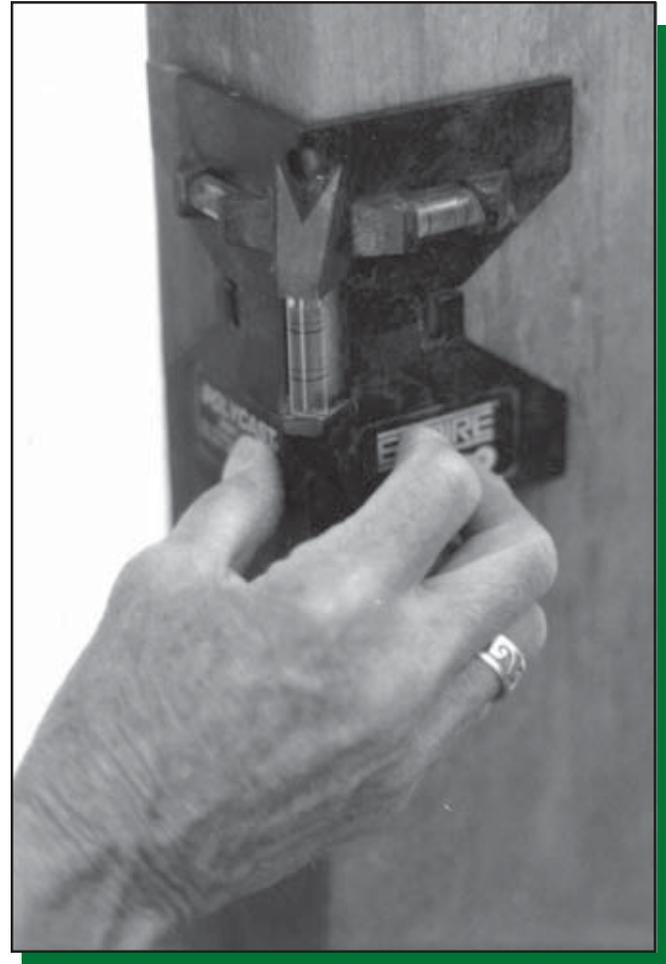


Figure 76—Post level.

find someone who knows how to run the instrument. A builders level or transit may be less accurate, but should work. A surveyors level rod will be needed to obtain distances and elevations. Distances can be quickly measured optically using stadia.

Electronic Distance Measuring Instruments

Two types of electronic distance-measuring instruments (EDMs) are available. The least expensive type is hand held and can measure distances across a flat surface to a point from 2 to 250 feet away. This type of instrument does not provide elevations of points or information needed to determine slopes and relative elevations. It will not provide accurate distance measurements if vegetation impedes the line of sight.



Construction Tools

More expensive instruments can measure distances up to 12,000 feet with an accuracy of 0.02 to 0.03 feet. This type of instrument can only be used where there is a direct, clear line of sight.

Global Positioning Systems

Global positioning systems (GPS) provide horizontal positioning through the use of coordinates and can provide elevations. This equipment may cost from a hundred dollars to several thousand dollars depending on the quality. The skills needed to operate GPS equipment vary depending on the equipment's sophistication and accuracy.

The accuracy of small hand-held instruments can be close to 1 meter (3.28 feet), in open, relatively level terrain, sufficient accuracy for trail work if frequent points are taken along the route.

High-resolution GPS instruments are also available for more precise work. These instruments require extensive training and experience in their use. They are also very expensive. This technology changes quickly. Technological advances and reduced costs, coupled with the recent relaxation of military security coding, suggest a much wider use of GPS in the future.

Saws

Handsaws

Most timbers and logs used in wetland trail construction are of relatively small diameter. Usually the largest are the piles, 6 to 10 inches in diameter.

If only a few pieces must be cut, or if wilderness regulations require, a one-person crosscut saw can do the job. This is an old-fashioned large handsaw. The blade is 3 to 4 feet long and heavier than a carpenter's handsaw, with much larger teeth (figure 77).



Figure 77—A one-person crosscut saw is a good choice for back-country settings.

Chain Saws

If many pieces of wood need to be cut, and if regulations permit them, chain saws do faster work for cutting the small sleepers, piles, and planks used for some wetland trails. A small, light-weight saw designed for tree pruning is better for cutting horizontally on vertical piles, posts, and other items. Pruning saws are available weighing 8 pounds, with a 12- to 14-inch bar.

The sawyer should be adequately trained and experienced in the use of the chain saw and the safety equipment. Most government agencies, the Forest Service included, require workers to receive special training and certification before they are allowed to use a chain saw.

Hand-Held Pruning Saws

Small hand-held pruning saws are used on most projects. Most types have a curved blade 12 to 26 inches long. For wetland work, the shorter saws are adequate. Some saws have a wood or plastic handle that the blade folds into when it is not being used. Small pruning saws with a straight blade 6 to 8 inches long are available. The short saws with the straight blade work well for cutting shallow notches in log sleepers. When the saws are folded, they can be carried in a pocket (figure 78).



Figure 78—Pruning saws.

Axes

Three kinds of axes are commonly used in trail work: single-bit, double-bit, and broad axes. The hatchet is not included in this tool list. A Maine guide once wrote that the hatchet is the most dangerous tool in the woods. He may have been right. It takes only one hand to use a hatchet. The other hand is often used to hold the piece of wood to be cut—not the safest thing to do. Few trail crews include a hatchet in their toolbox.

Proper ax selection, care, and use is described in MTDC's videos and reports: *An Ax to Grind: A Practical Ax Manual* (9923-2823-MTDC) and *Handtools for Trail Work* (8823-2601-MTDC).

Adzes

If the hatchet is the most dangerous handtool in the woods, the carpenters adz is the second most dangerous. A person getting hurt with a hatchet has usually been careless. It is not necessary to be careless to get hurt using an adz. The carpenters adz is used for cutting a level surface on a log for some types of puncheon and gadbury and for removing knots and bulges on log surfaces.

The blade of a carpenters adz is 5 inches wide and similar to an ax except that it is mounted perpendicular to the line of the handle, similar to a hoe. The edge must be sharp. The handle is curved, similar to a fawn's-foot handle on a single-bit ax.

Workers using an adz normally stand on a wide log (16 inches or more in diameter) and swing the adz toward their feet, almost like hoeing a garden. An adz can be used on smaller-diameter logs by a worker standing next to the log and chopping sideways along the length of the log. When one face of the log is cut to a level plane, the log can be turned and another face can be cut. It is extremely difficult to use a long-handled adz to cut anything but the upper surface of a log.

Two other types of carpenters adzes have short handles. They are not suitable for shaping large logs, but work well for removing knots and bulges and for cutting notches. Short-handled adzes are made with a straight or concave blade, about 3 inches wide. Striking the back of the adz head with a hammer will eventually crack the head (figure 79).



Figure 79—Using an adz safely requires that the adz has a razor-sharp edge and that the worker use the utmost control and concentration when making the swing.

Planes

Small block planes can be used for shaping bevels and chamfers, for removing unevenness where two pieces of wood butt together, and for smoothing splintery edges that visitors might touch. Block planes are small, about 2 inches wide and 4 inches long, and easily packed to the work site (figure 80).

Draw Knives

Draw knives are often used to peel the bark off logs. Logs will last longer without the bark. Draw knives work best on logs with thin bark.